

## PATENT ABSTRACTS OF JAPAN

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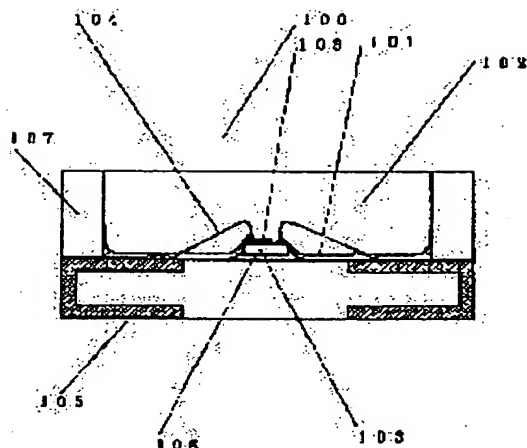
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## (54) LIGHT EMITTING DEVICE

## (57)Abstract:

PROBLEM TO BE SOLVED: To improve the light pickup efficiency from a light emitting device, by laying a light scattering layer on the bottom of a recess around an LED chip, and providing a light-permeable sealing material for protecting the LED chip in the recess.

SOLUTION: A light scattering layer 101 is to pick up a light emitted with a lateral vector from an LED chip 103, without guiding in a light-permeable sealing material 102 and hence may be any one which is disposed around the LED chip 103 and capable of efficiently scattering/diffusion reflecting a light from the LED chip 103. A resin contg. a light-scattering/diffusing inorg. member has pref. a high permeability to the light from the LED chip and high adhesion to the diffusing material, light-permeable seal 102 and package 107 and high heat resistance. The light scattering layer 107 can be comparatively simply formed by pouring and hardening the resin in a recess of the package 107 where the LED chip 103 is previously disposed.



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CLAIMS

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[Claim(s)]

[Claim 1] Luminescence equipment characterized by having the light-scattering layer arranged on the crevice base of said perimeter of an LED chip, and the translucency sealing agent which protects an LED chip in said crevice in the luminescence equipment with which the LED chip has been arranged on the base of the package which has a smooth crevice.

[Claim 2] The thickness of said light-scattering layer is luminescence equipment [ thinner than height ] according to claim 1 from the crevice base of an LED chip to a luminous layer.

[Claim 3] Said light-scattering layer is luminescence equipment according to claim 1 currently colored the luminescent color and abbreviation identitas of an LED chip.

[Claim 4] Said LED chip is luminescence equipment according to claim 1 which consists of a nitride semi-conductor made into terrorism structure to double through the barrier layer on silicon on sapphire:

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention is to offer the luminescence equipment which raised the optical ejection effectiveness from an LED chip more especially with respect to the luminescence equipment using an available LED chip to the write-in light source, the light source for back lights, etc. of various indicators, a display, and an optical printer.

[0002]

[Description of the Prior Art] Although used as the various light sources, an LED chip is mentioned to one today. An LED chip is a semi-conductor light emitting device, does not have a ball piece, and is excellent in the ON/OFF drive property. Moreover, it is a low power, and since it has monochromatic peak wavelength, it is used for various fields. Such an LED chip is usually very as small as about 300-micrometer angle extent. Therefore, the chip type LED which arranged the LED chip inside the package with which the lead electrode in which a flow with the exterior is possible was embedded from the purpose which raises the ease of dealing with it, such as arrangement and electrical installation, and efficiency for light utilization to a loading substrate is used.

[0003] Specifically, the package 407 with which the lead electrode 405 was embedded into the liquid crystal polymer as an envelope which protects the LED chip 403 from the exterior is used like drawing 4. There is a crevice in a package 407 and some lead electrodes 405 are exposed to the interior. As for some exposed lead electrodes 405 and the electrode of the LED chip 403 fixed to the interior of a package by die bond resin 406, the electric flow is taken by the gold streak 404 etc. It is covered with the translucency epoxy resin 402 in order to protect the LED chip 403 in the crevice of a package 407. In this way, if a current is supplied to the formed chip type LED 400, the LED chip 403 will emit light, it will directly or once reflect in the chip type [ 400 ] LED exterior on the base and side face of a package through the translucency sealing agent 402 from the LED chip 403, and light will be emitted to the exterior of a package.

[0004]

[Problem(s) to be Solved by the Invention] It is reflected by the base of the smooth metal lead electrode 405 or a smooth package, and the light which went to the crevice base side of a package 407 among the light in which the LED chip 403 emitted light is efficiently taken out by the exterior of luminescence equipment through the translucency epoxy resin 402.

[0005] However, in today when optical higher ejection effectiveness is searched for with a low power, the luminescence equipment of the above-mentioned configuration is not enough, and improvement in the further optical extraction effectiveness is called for. Therefore, this invention cancels the above-mentioned trouble and forms the high luminescence equipment of optical extraction effectiveness more.

[0006]

[Means for Solving the Problem] This invention has the light-scattering layer arranged on the crevice base of the perimeter of an LED chip, and the translucency sealing agent which protects an LED chip in a crevice in the luminescence equipment with which the LED chip has been arranged on the base of the package which has a smooth crevice. The package base which

reflects in a front face efficiently the light emitted from the LED chip by this comparatively easy configuration, the front face of a lead electrode, and the light-scattering layer which is made to scatter about for it and diffuse the light by which total reflection was carried out with the translucency sealing agent, and is taken out outside efficiently are made to carry out functional separation. This raises the optical extraction effectiveness from luminescence equipment. That is, originally the shape of a mirror plane has [ the light emitted from an LED chip ] a high reflection factor. However, there are some which total reflection of the light from an LED chip is carried out with a translucency sealing agent, and are shut up. While the true down one of an LED chip makes this invention a flat reflector, the light by which total reflection is carried out with translucency resin is scattered about and diffused in a light-scattering layer.

[0007] The substantial thickness of a light-scattering layer of the luminescence equipment of this invention according to claim 2 is thinner than height from the crevice base of an LED chip to a luminous layer. Thereby, the luminescence brightness emitted from the edge of a luminous layer is not reduced. Moreover, the light by which critical reflection is carried out can be chosen and external extraction effectiveness can be raised.

[0008] The light-scattering layer is coloring the luminescence equipment of this invention according to claim 3 the luminescent color and abbreviation identitas of an LED chip. Thereby, an LED chip does not emit light in a package at punctiform. That is, a light-emitting part can be more greatly observed as the LED chip is arranged like the time of an astigmatism LGT at the whole opening at the time of lighting.

[0009] The luminescence equipment of this invention according to claim 4 consists of a nitride semi-conductor which the LED chip made terrorism structure to double through the barrier layer on silicon on sapphire. By this, it can consider as the luminescence equipment which may raise optical extraction effectiveness by leaps and bounds.

[0010]

[Embodiment of the Invention] this invention person came to accomplish header this invention for luminous efficiency becoming good rapidly by arranging the light-scattering layer which scatters the light from an LED chip over the base of the package with which an LED chip is arranged as a result of various experiments.

[0011] That is, this invention raises optical extraction effectiveness by changing the structure of luminescence equipment by the course of the light emitted from an LED chip.

[0012] If it states more concretely, drawing 2 shows typically the path of the light by which outgoing radiation was carried out the include angle [ chip / LED ]  $\theta$  beyond a critical angle with an example of the luminescence equipment shown for this invention and a comparison. Critical angle reflection of the light 208 which has an include angle beyond the critical angle by which outgoing radiation was carried out from the point 203 of the LED chip seen typically emitting light is carried out in the direction of the symmetry at the same include angle as an incident angle by the interface of the translucency sealing agent 202 and the exterior. Incidence of the light 209 by which critical angle reflection was carried out is carried out to a lead electrode or a package base, and it is reflected in the direction of the symmetry at the same include angle as incidence in this front face.

[0013] Again, incidence is carried out to the interface of a translucency sealing agent and the exterior, critical angle reflection is carried out at the same include angle, and this light 210 goes in the direction of the interior of a package. Thus, as long as there is no include-angle-change in the base or lead electrode of a package and it is a smooth side substantially, the course of the light 208 by which outgoing radiation was carried out from the LED chip above the critical angle penetrates the interior of the translucency sealing agent 203, and repeats reflection in an interface, and the lead electrode and package base of the translucency sealing agent 202. In the meantime, there is that [ no ] the transmission of the translucency sealing agent 202 and whose reflection factor at a lead electrode and the base of a package are completely 1. Therefore, whenever transparency and reflection are repeated once each, light will absorb with a  $(1 - \text{permeability} \times \text{reflection factor})$ , and it will disappear. Since a high thing or about 90%, and a reflection factor are also about 90% also in a high reflective metal member, if resin permeability repeats transparency reflection 3 times, 50% or more of light will disappear among the outgoing

radiation light beyond a critical angle.

[0014] Drawing 3 shows typically the course of the light by which outgoing radiation was carried out the include angle [ chip / LED ] beyond a critical angle like drawing 2 in the luminescence equipment of this invention.

[0015] The light by which outgoing radiation was carried out the include angle  $\theta$  beyond a critical angle from the point 303 of the LED chip seen typically emitting light reaches the light-scattering layer 301 which critical angle reflection is carried out by the interface of the translucency sealing agent 302 and the exterior, and has dispersion and diffuse reflection nature toward the interior. the light which reached the light-scattering layer 301 -- dispersion -- it spreads and reflects and scatter reflection is carried out to the course 310 of semi-sphere-like light. The light 302 below a critical angle is taken out from the translucency sealing agent 302 outside as it is among the scattered lights. Moreover, although the light beyond the critical angle of the scattered light also carries out critical angle reflection by the interface of the translucency sealing agent 302 and the exterior, if the light-scattering layer 301 is reached again, it will be made to be the same as that of \*\*\*\* dispersion and diffuse reflection. Therefore, the great portion of light which carried out critical angle reflection is taken out outside.

[0016] On the other hand, it is efficiently reflected in respect of being flat, and the light 311 which went to true down one from the LED chip 303 is taken out outside through the translucency sealing agent 302. Thus, in this invention, luminous efficiency is raised by using effectively separately the light which goes in the light which goes to the package base side direction where the LED chip has been arranged among the light once emitted from the LED chip 303, and the direction of a package side attachment wall, respectively. In addition, the critical angle in this invention points out the critical angle  $\alpha$  between a translucency sealing agent and outer space, and it defines as follows. They are the refractive index of an  $n_1$ = translucency sealing agent, and the refractive index of  $n_2$ = outer space in critical angle  $\alpha = \sin^{-1}(n_2/n_1)$  and here.

[0017] Moreover, since an LED chip confines a current in double with the LED chip of terrorism structure, the presentation of a semi-conductor has been changed. Therefore, the refractive indexes of a luminous layer and the cladding layer which sandwiched the luminous layer differ. The light produced from this in the luminous layer plays the role like a kind of waveguide. Therefore, the light emitted from the edge of a luminous layer increases. Whether the light emitted from this edge can be used effectively will contribute to efficiency for light utilization greatly.

[0018] Furthermore, generally the LED chip using a nitride semi-conductor is formed on sapphire from the physical properties of that crystal growth is difficult and a nitride semi-conductor. For this reason, the electrode of a positive electrode and a negative electrode is formed in the semi-conductor laminating side side formed on silicon on sapphire. moreover, a luminous layer top -- a whole wrap surface electrode is mostly formed for a front face. The electrode material which can take such ohmic contact is restricted, and light is taken out through this metal-electrode layer. Since translucency is given by using a metal-electrode layer as a thin film, there is light surely reflected by the metal-electrode layer. Therefore, as for the LED chip using a nitride semi-conductor, the leakage of a lateral light tends to become large. Hereafter, 1 operation gestalt of this invention is shown.

[0019] Manufacture of luminescence equipment mounts first the LED chip which consists of AlGaInP as a light emitting device with Ag paste using a die bond device in the crevice of a package. In addition, the rear-face electrode of the LED chip in contact with Ag paste is used as smooth and the metal electrode which reflects the light of an LED chip efficiently. Wire bond of the electrode by the side of the luminescence side of the mounted LED chip and the lead electrode of a package is carried out using a wirebonding device. Next, the resin with which the dispersing agent was mixed is poured in into the crevice of the package of the LED chip circumference.

[0020] After impregnation, a dispersing agent flows and is a wrap about the base of a package. After stiffening the resin of dispersing agent content, impregnation hardening of the resin of a translucency sealing agent is carried out, and the luminescence equipment of this invention is

completed. By this, it can consider as the high luminescence equipment of optical extraction effectiveness. Hereafter, the configuration member of this invention is explained in full detail. [0021] (Light-scattering layer 101) The light-scattering layer 101 of this invention is for taking out outside, without carrying out the guided wave of the light emitted with the lateral vector from the LED chip 103 within the translucency sealing agent 102. Therefore, to be arranged around the LED chip 103 and what is necessary is just dispersion and the thing which can carry out diffuse reflection efficiently about the light from the LED chip 103. Specifically, the inorganic member of light scattering and diffusibility, such as titanium oxide, barium titanate, an aluminum oxide, oxidization silicon, titanium oxide, a zinc oxide, a piece of a metal, and various fluorescent substances, is mentioned. Furthermore, it can change into an inorganic member and organic resin, such as melamine resin, CTU guanamine resin, and benzoguanamine resin, can also be used.

[0022] It is desirable for translucency to be high to the light from the LED chip 103 as resin which the inorganic member of light scattering and diffusibility contains, and for adhesion with a dispersing agent, the translucency sealing agent 102, and a package 107 and thermal resistance to be high. As such resin, a silicone system, an epoxy system, acrylic resin, etc. are specifically used suitably. The light-scattering layer 101 can be made to form comparatively simply by slushing into the crevice of the package 107 with which the LED chip 103 has been arranged beforehand, and stiffening it. If viscosity of the resin which constitutes the light-scattering layer 101 is made low, it will be easy to spread in the crevice of a package 107. Therefore, it creeps up to the side face which constitutes not only the base of a package 107 but the crevice of a package, or the side face of the LED chip 103.

[0023] Since the LED chip 103 using a nitride semi-conductor has much light emitted from the end face of a luminous layer, using effectively well the light emitted from an end face has big effectiveness especially. If the height of the luminous layer of the LED chip 103 from package 107 base is higher than the thickness of the light-scattering layer 101, the light emitted from an end face will be emitted effectively. Then, by the interface of translucency resin 102 and the exterior, the light which carried out total reflection is a light-scattering layer, and is emitted isotropic.

[0024] Moreover, a light-scattering layer creeps up partially, and since the luminous layer of an LED chip becomes is easy to be emitted it is thin and isotropic [ a wrap case ] from an LED chip end face, light can also be used effectively. Also in this case, the thickness of a light-scattering layer becomes thinner than the height of a luminous layer. this -- creeping up -- it is controllable to some extent by adjusting the viscosity of the resin which constitutes a light-scattering layer. Such a light-scattering layer can obtain uniform luminescence with the comparatively easy configuration of only making a light-scattering layer form on a smooth package.

[0025] (Translucency sealing agent 102) The translucency sealing agent 102 is formed in the crevice of a package 107, and it protects the LED chip 103, a wire 104, etc. from external force, dust, etc. while making the light from the LED chip 103 penetrate outside efficiently. As such a translucency sealing agent 102, an epoxy resin, silicone resin, acrylic resin, etc. are used suitably. In order to give the screen effect etc. to the light from the LED chip 103 into the translucency sealing agent 102, it can add with a coloring color or a color pigment.

[0026] (LED chip 103) the LED chip 103 -- MOCVD -- it can form with law, a liquid phase grown method, etc. by carrying out the laminating of the semi-conductor luminous layers, such as GaP, GaAlAs, GaAlInP, InN, GaN and AlN, InGaP, and InGaAlN, on a substrate. The thing of terrorism structure is mentioned to the gay structure of having MIS junction, PIN junction, pn junction, etc. as structure of an LED chip, hetero structure, and double. Especially through a barrier layer, the light generated in the barrier layer 108 spreads the inside of a barrier layer to double like a waveguide, and the thing of terrorism structure is easy to be emitted to it from the end face of a barrier layer. Therefore, the effectiveness of this invention is large.

[0027] Similarly, a nitride semi-conductor ( $\text{In}_x\text{Ga}_y\text{Al}_{1-x-y}\text{N}$ ,  $0 \leq x$ ,  $0 \leq y$ ,  $0 \leq x+y \leq 1$ ) is formed on insulating silicon on sapphire with difficult crystal growth. in order to supply power to the nitride semi-conductor formed on silicon on sapphire -- a positive electrode and a negative

electrode -- the same field side -- not forming -- it does not obtain, but ohmic contact and in order to make a current pour in efficiently, a golden thin film etc. is used as an electrode of translucency. Although such an electrode is used as a thin film, and is giving translucency and it consists of a metal therefore, the light generated by the barrier layer of an LED chip is reflected partially. Therefore, there is much light emitted from an edge and especially the LED chip using a nitride semi-conductor has the large effectiveness of this invention.

[0028] Such an LED chip 103 can use and mount a die bond device on a package 107. Moreover, it can be made to connect with the electrode prepared on the LED chip electrically using wire 104 grade.

[0029] (Package 107) The lead electrode 105 which a package 107 makes arrange the LED chip 103, and supplies the current from the outside to the LED chip 103 is formed. As a concrete ingredient of such a package 107, insulating supporter material, such as ceramics, and a liquid crystal polymer, PBT resin, is mentioned suitably. In order to take out the light from the LED chip 103 efficiently, a thing with a side attachment wall is suitably mentioned to a package 107.

[0030] When carrying out mold shaping of the package 107 with resin, the lead electrode 105 which supplies power to the LED chip 103 arranged inside can be formed comparatively easily by insert molding etc. The lead electrode 105 can be formed with electric good conductors, such as metallizing, such as nickel, or phosphor bronze. In order to raise the reflexivity of the light from the LED chip 103, smooth metal plating, such as silver, aluminum, and copper metallurgy, can also be performed to the front face of the lead electrode 105. In order to reflect the light from the LED chip 103 efficiently, the resin which constitutes a package 107 can be made to mix white pigments, such as barium titanate, etc.

[0031] When making a ceramic constitute a package 107, the conductive paste which contained the refractory metal by the desired pattern on the green sheet used as the raw material before ceramic baking is printed. It calcinates, after setting a green sheet in two or more [-fold] and making it a package configuration, and a ceramic package is formed. A conductive paste remains as an electrode layer in which electrical installation with the jump exterior has a possible resinous principle at the time of baking.

[0032] In addition, a smooth package base means the flat surface which can be reflected in the specific direction like a mirror plane for the great portion of light from the LED chip 103 which carried out incidence from fixed. The light of the lengthwise direction emitted from the LED chip 103 arranged on such a flat surface can be efficiently emitted to a front face. It cannot be overemphasized that it is not what is limited only to this hereafter although the concrete example of this invention is explained in full detail.

[0033]

[Example] The LED chip which had the nitride semi-conductor with which blue (470nm) can emit light in the luminous layer as a chip type LED was arranged in the resin package. The laminating of the buffer layer to which an LED chip consists of gallium nitride on silicon on sapphire, n mold contact-cum-the cladding layer which consists of GaN, p mold cladding layer which consists of GaAlN, and the p mold contact layer which consists of GaN is carried out. Between n mold contact layer and p mold cladding layer, the InGaN layer used as single quantum well structure is formed. In order to make the electrode of a positive electrode and a negative electrode form from the semi-conductor layer side formed on silicon on sapphire, some nitride semi-conductors are made to etch and n mold contact layer is exposed. The golden thin film is made to have formed as an ohmic electrode on p mold contact layer.

[0034] Molding of the package was carried out by arranging the lead electrode made to form beforehand in metal mold, and carrying out impregnation hardening of the liquid crystal polymer. Some lead electrodes have exposed the formed package to the base of opening, and the front face of a lead electrode, the base of a package, and the side face have made light from an LED chip the efficient smooth side which can be reflected.

[0035] The translucency epoxy resin was used and the above-mentioned LED chip was made to mount using a die bonding device in opening of a package. Wirebonding of each electrode of an LED chip and the lead electrode in package opening is carried out using a gold streak, and the flow is taken electrically.



[0036] It was made to pour into package opening circles, carrying out mixed churning of the thing which made 5g of barium titanate, and a blue color contain in 100g of silicone resin as a light-scattering layer. It was made to harden in 150-degree-C 30 minutes, and the light-scattering layer was made to form after impregnation. Although the height of the formed light-scattering layer was lower than the luminous layer of an LED chip, the light-scattering layer was creeping up thinly at the edge. Into the crevice of a package, impregnation hardening has been carried out by using an epoxy resin as a translucency sealing agent in 120-degree-C 2 hours. In this way, 500 chip types LED were formed and the luminescence property was investigated.

[0037] 500 chip types LED as well as the chip type LED of this invention were made to form except not forming a light-scattering layer for a comparison.

[0038] Although all emitted light when the current was supplied to the formed chip type LED, as for the chip type LED in which the whole opening made the chip type LED of this invention form to emitting light blue for this invention and a comparison, light is notably emitted near the LED chip blue. Moreover, the average luminescence brightness of the chip type LED which did not prepare a light-scattering layer was set to 100, and the chip type LED which prepared the light-scattering layer was increased about twenty percent, and was detected brightly. Thereby, it turned out with the configuration with the very easy luminescence equipment of this invention that a radiant power output may be improved sharply.

[0039]

[Effect of the Invention] The light-scattering layer which is made to scatter about for it and diffuse the reflecting surface reflected in the front face of direct from an LED chip and the light by which total reflection was carried out with the translucency sealing agent, and is efficiently taken out outside by the configuration of this invention is made to carry out functional separation. This raises the optical extraction effectiveness from luminescence equipment. Moreover, when arranging in a package the LED chip which emits light in the luminescence wavelength from which plurality differs, since light spreads in homogeneity by the light-scattering layer, light can be emitted with sufficient color mixture nature.

[0040] With the luminescence equipment of this invention according to claim 2, it takes out without affecting luminescence [ chip / LED ], and only effectiveness may be improved. That is, the luminescence brightness emitted from the edge of a luminous layer is not reduced. Moreover, the light by which critical reflection is carried out can be chosen and external extraction effectiveness can be raised.

[0041] With the luminescence equipment of this invention according to claim 3, an LED chip does not emit light in a package at punctiform. That is, a light-emitting part can be more greatly observed as the LED chip is arranged like the time of an astigmatism LGT at the whole opening at the time of lighting. For example, if the luminescence wavelength of a light emitting device is a blue field, it can also make to consider as \*\*\*\*\* etc. into a color with a high reflection factor only to the luminescent color by adding the blue system pigment of light scattering and diffusibility to a light-scattering layer. In this case, if the luminescent color of a light emitting device and the color of a light-scattering layer are doubled, it will also become possible not to make the luminescent color of luminescence equipment actually emit light, but to distinguish it easily visually.

[0042] With the luminescence equipment of this invention according to claim 4, when it is a light emitting device with much lateral light emission, optical extraction effectiveness can be raised by leaps and bounds.

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## DESCRIPTION OF DRAWINGS

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### [Brief Description of the Drawings]

[Drawing 1] The chip type LED typical sectional view by one example of this invention is shown.

[Drawing 2] In the chip type LED shown for this invention and a comparison, the course of the light by which outgoing radiation was carried out the include angle [ chip / LED ] beyond a critical angle is shown typically.

[Drawing 3] In the chip type LED of this invention, the path of the light by which outgoing radiation was carried out the include angle [ chip / LED ] beyond a critical angle is shown typically.

[Drawing 4] It is the typical sectional view of the chip type LED shown for this invention and a comparison.

### [Description of Notations]

100 ... Luminescence equipment

101 ... Light-scattering layer

102 ... Translucency sealing agent

103 ... LED chip

104 ... Wire

105 ... Lead electrode

106 ... Mounting resin

107 ... Package

108 ... Barrier layer

200 ... Luminescence equipment

202 ... Translucency resin

203 ... Point of the LED chip seen typically emitting light

208 ... Light by which outgoing radiation was carried out from the LED chip above the critical angle

209 ... Light by which critical angle reflection was carried out

210 ... Light repeatedly reflected with a translucency sealing agent

301 ... Light-scattering layer

302 ... Translucency resin

303 ... Point of the LED chip seen typically emitting light

308 ... Light by which outgoing radiation was carried out from the LED chip above the critical angle

309 ... Light by which critical angle reflection was carried out

310 ... Light which diffuses and reflects and is emitted in the shape of a semi-sphere

311 ... Light which goes to true down one from an LED chip

400 ... Luminescence equipment

402 ... Translucency sealing agent

403 ... LED chip

404 ... Gold streak

405 ... Lead electrode

406 ... Die bond resin

407 ... Package

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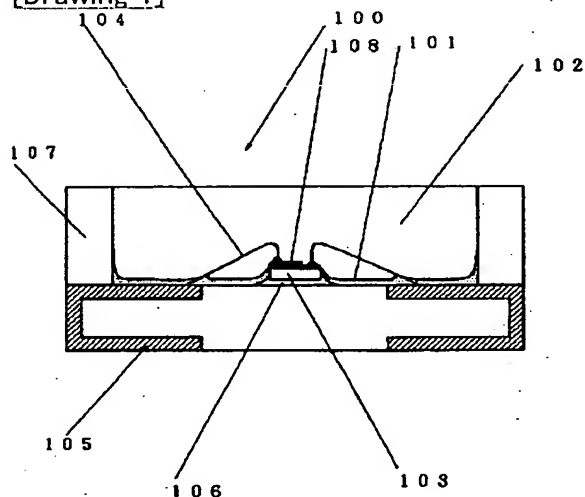
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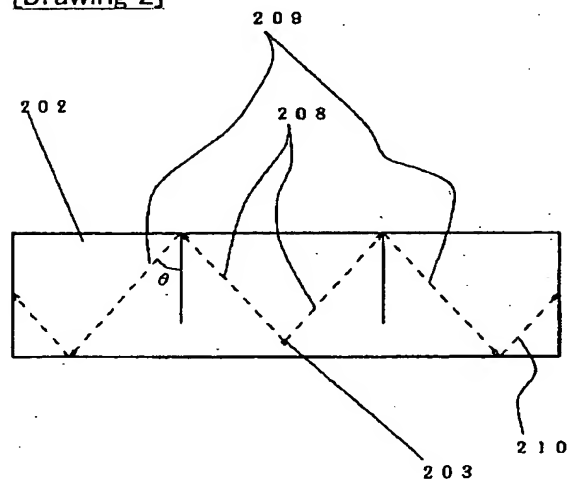
DRAWINGS

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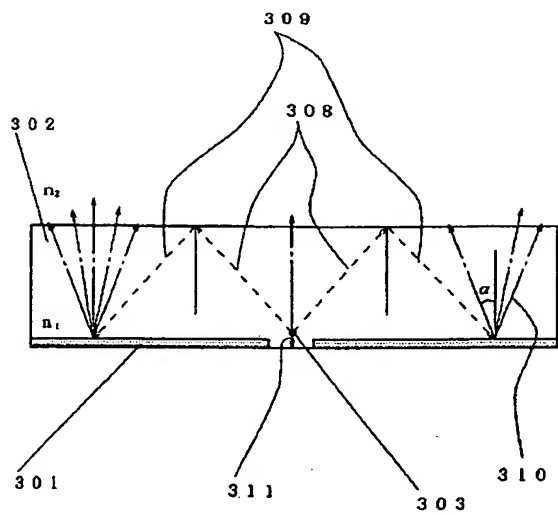
[Drawing 1]



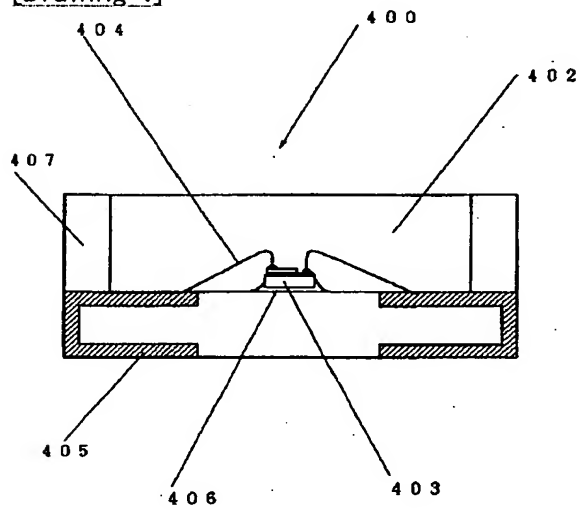
[Drawing 2]



[Drawing 3]



[Drawing 4]



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CORRECTION OR AMENDMENT

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[Procedure amendment 1]

[Document to be Amended] Specification

[Item(s) to be Amended] Whole sentence

[Method of Amendment] Modification

[Proposed Amendment]

[Document Name] Specification

[Title of the Invention] Luminescence equipment

[Claim(s)]

[Claim 1] In the luminescence equipment with which the LED chip has been arranged on the base of the crevice of a package,

Luminescence equipment characterized by having the light-scattering layer which was missing from the side face of said crevice, and has been arranged from said base of said perimeter of an LED chip, and the translucency sealing agent which protects said LED chip in said crevice.

[Claim 2] Luminescence equipment according to claim 1 with the thickness of said light-scattering layer thinner than the height from said base to the luminous layer of said LED chip.

[Claim 3] Said light-scattering layer is luminescence equipment according to claim 1 or 2 currently colored the luminescent color and abbreviation identitas of said LED chip.

[Claim 4] Said LED chip is luminescence equipment according to claim 1 to 3 which consists of a nitride semi-conductor made into terrorism structure to double through the barrier layer on silicon on sapphire.

[Claim 5] Said light-scattering layer is luminescence equipment according to claim 1 to 4 which the fluorescent substances various [ a kind of ] chosen from titanium oxide, barium titanate, an aluminum oxide, oxidation silicon, and a zinc oxide contain at least.

## [Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention is to offer the luminescence equipment which raised the optical ejection effectiveness from an LED chip more especially with respect to the luminescence equipment using an available LED chip to the write-in light source, the light source for back lights, etc. of various indicators, a display, and an optical printer.

[0002]

[Description of the Prior Art] Although used as the various light sources, an LED chip is mentioned to one today. An LED chip is a semi-conductor light emitting device, does not have a ball piece, and is excellent in the ON/OFF drive property. Moreover, it is a low power, and since it has monochromatic peak wavelength, it is used for various fields. Such an LED chip is usually very as small as about 300-micrometer angle extent. Therefore, the chip type LED which arranged the LED chip inside the package with which the lead electrode in which a flow with the exterior is possible was embedded from the purpose which raises the ease of dealing with it, such as arrangement and electrical installation, and efficiency for light utilization to a loading substrate is used.

[0003] Specifically, the package 407 with which the lead electrode 405 was embedded into the liquid crystal polymer as an envelope which protects the LED chip 403 from the exterior is used like drawing 4. There is a crevice in a package 407 and some lead electrodes 405 are exposed to the interior. As for some exposed lead electrodes 405 and the electrode of the LED chip 403 fixed to the interior of a package by die bond resin 406, the electric flow is taken by the gold streak 404 etc. It is covered with the translucency epoxy resin 402 in order to protect the LED chip 403 in the crevice of a package 407. In this way, if a current is supplied to the formed chip type LED 400, the LED chip 403 will emit light, it will directly or once reflect in the chip type [ 400 ] LED exterior on the base and side face of a package through the translucency sealing agent 402 from the LED chip 403, and light will be emitted to the exterior of a package.

[0004]

[Problem(s) to be Solved by the Invention] It is reflected by the base of the smooth metal lead electrode 405 or a smooth package, and the light which went to the crevice base side of a package 407 among the light in which the LED chip 403 emitted light is efficiently taken out by the exterior of luminescence equipment through the translucency epoxy resin 402.

[0005] However, in today when optical higher ejection effectiveness is searched for with a low power, the luminescence equipment of the above-mentioned configuration is not enough, and improvement in the further optical extraction effectiveness is called for. Therefore, this invention cancels the above-mentioned trouble and forms the high luminescence equipment of optical extraction effectiveness more.

[0006]

[Means for Solving the Problem] This invention has the light-scattering layer which was missing from the side face of said crevice, and has been arranged from said base of said perimeter of an LED chip, and the translucency sealing agent which protects said LED chip in said crevice in the luminescence equipment with which the LED chip has been arranged on the base of the crevice of a package. The package base which reflects in a front face efficiently the light emitted from the LED chip by this comparatively easy configuration, the front face of a lead electrode, and the light-scattering layer which is made to scatter about for it and diffuse the light by which total reflection was carried out with the translucency sealing agent, and is taken out outside efficiently are made to carry out functional separation. This raises the optical extraction effectiveness from luminescence equipment. That is, originally the shape of a mirror plane has [ the light emitted from an LED chip ] a high reflection factor. However, there are some which total reflection of the light from an LED chip is carried out with a translucency sealing agent, and are shut up. While the true down one of an LED chip makes this invention a flat reflector, the light by which total reflection is carried out with translucency resin is scattered about and diffused in a light-scattering layer.

[0007] The substantial thickness of a light-scattering layer of the luminescence equipment of this invention according to claim 2 is thinner than height from the crevice base of an LED chip to

a luminous layer. Thereby, the luminescence brightness emitted from the edge of a luminous layer is not reduced. Moreover, the light by which critical reflection is carried out can be chosen and external extraction effectiveness can be raised.

[0008] The light-scattering layer is coloring the luminescence equipment of this invention according to claim 3 the luminescent color and abbreviation identitas of an LED chip. Thereby, an LED chip does not emit light in a package at punctiform. That is, a light-emitting part can be more greatly observed as the LED chip is arranged like the time of an astigmatism LGT at the whole opening at the time of lighting.

[0009] The luminescence equipment of this invention according to claim 4 consists of a nitride semi-conductor which the LED chip made terrorism structure to double through the barrier layer on silicon on sapphire. By this, it can consider as the luminescence equipment which may raise optical extraction effectiveness by leaps and bounds. The luminescence equipment of this invention according to claim 5 contains the light-scattering layer which the fluorescent substances various [ a kind of ] chosen from titanium oxide, barium titanate, an aluminum oxide, oxidation silicon, and a zinc oxide contain at least. By this, light from an LED chip is made dispersion and diffuse reflection efficiently.

[0010]

[Embodiment of the Invention] this invention person came to accomplish header this invention for luminous efficiency becoming good rapidly by arranging the light-scattering layer which scatters the light from an LED chip over the base of the package with which an LED chip is arranged as a result of various experiments.

[0011] That is, this invention raises optical extraction effectiveness by changing the structure of luminescence equipment by the course of the light emitted from an LED chip.

[0012] If it states more concretely, drawing 2 shows typically the path of the light by which outgoing radiation was carried out the include angle [ chip / LED ]  $\theta$  beyond a critical angle with an example of the luminescence equipment shown for this invention and a comparison. Critical angle reflection of the light 208 which has an include angle beyond the critical angle by which outgoing radiation was carried out from the point 203 of the LED chip seen typically emitting light is carried out in the direction of the symmetry at the same include angle as an incident angle by the interface of the translucency sealing agent 202 and the exterior. Incidence of the light 209 by which critical angle reflection was carried out is carried out to a lead electrode or a package base, and it is reflected in the direction of the symmetry at the same include angle as incidence in this front face.

[0013] Again, incidence is carried out to the interface of a translucency sealing agent and the exterior, critical angle reflection is carried out at the same include angle, and this light 210 goes in the direction of the interior of a package. Thus, as long as there is no include-angle-change in the base or lead electrode of a package and it is a smooth side substantially, the course of the light 208 by which outgoing radiation was carried out from the LED chip above the critical angle penetrates the interior of the translucency sealing agent 203, and repeats reflection in an interface, and the lead electrode and package base of the translucency sealing agent 202. In the meantime, there is that [ no ] the transmission of the translucency sealing agent 202 and whose reflection factor at a lead electrode and the base of a package are completely 1. Therefore, whenever transparency and reflection are repeated once each, light will absorb with a  $(1 - \text{permeability} \times \text{reflection factor})$ , and it will disappear. Since a high thing or about 90%, and a reflection factor are also about 90% also in a high reflective metal member, if resin permeability repeats transparency reflection 3 times, 50% or more of light will disappear among the outgoing radiation light beyond a critical angle.

[0014] Drawing 3 shows typically the course of the light by which outgoing radiation was carried out the include angle [ chip / LED ] beyond a critical angle like drawing 2 in the luminescence equipment of this invention.

[0015] The light by which outgoing radiation was carried out the include angle  $\theta$  beyond a critical angle from the point 303 of the LED chip seen typically emitting light reaches the light-scattering layer 301 which critical angle reflection is carried out by the interface of the translucency sealing agent 302 and the exterior, and has dispersion and diffuse reflection nature



toward the interior. the light which reached the light-scattering layer 301 -- dispersion -- it spreads and reflects and scatter reflection is carried out to the course 310 of semi-sphere-like light. The light 302 below a critical angle is taken out from the translucency sealing agent 302 outside as it is among the scattered lights. Moreover, although the light beyond the critical angle of the scattered light also carries out critical angle reflection by the interface of the translucency sealing agent 302 and the exterior, if the light-scattering layer 301 is reached again, it will be made to be the same as that of \*\*\*\* dispersion and diffuse reflection. Therefore, the great portion of light which carried out critical angle reflection is taken out outside.

[0016] On the other hand, it is efficiently reflected in respect of being flat, and the light 311 which went to true down one from the LED chip 303 is taken out outside through the translucency sealing agent 302. Thus, in this invention, luminous efficiency is raised by using effectively separately the light which goes in the light which goes to the package base side direction where the LED chip has been arranged among the light once emitted from the LED chip 303, and the direction of a package side attachment wall, respectively. In addition, the critical angle in this invention points out the critical angle  $\alpha$  between a translucency sealing agent and outer space, and it defines as follows. They are the refractive index of an  $n_1$ = translucency sealing agent, and the refractive index of  $n_2$ = outer space in critical angle  $\alpha = \sin^{-1}(n_2/n_1)$  and here.

[0017] Moreover, since an LED chip confines a current in double with the LED chip of terrorism structure, the presentation of a semi-conductor has been changed. Therefore, the refractive indexes of a luminous layer and the cladding layer which sandwiched the luminous layer differ. The light produced from this in the luminous layer plays the role like a kind of waveguide. Therefore, the light emitted from the edge of a luminous layer increases. Whether the light emitted from this edge can be used effectively will contribute to efficiency for light utilization greatly.

[0018] Furthermore, generally the LED chip using a nitride semi-conductor is formed on sapphire from the physical properties of that crystal growth is difficult and a nitride semi-conductor. For this reason, the electrode of a positive electrode and a negative electrode is formed in the semi-conductor laminating side side formed on silicon on sapphire. moreover, a luminous layer top -- a whole wrap surface electrode is mostly formed for a front face. The electrode material which can take such ohmic contact is restricted, and light is taken out through this metal-electrode layer. Since translucency is given by using a metal-electrode layer as a thin film, there is light surely reflected by the metal-electrode layer. Therefore, as for the LED chip using a nitride semi-conductor, the leakage of a lateral light tends to become large. Hereafter, 1 operation gestalt of this invention is shown.

[0019] Manufacture of luminescence equipment mounts first the LED chip which consists of AlGaInP as a light emitting device by Ag paste by the die bond device in the crevice of a package. In addition, the rear-face electrode of the LED chip in contact with Ag paste is used as smooth and the metal electrode which reflects the light of an LED chip efficiently. Wire bond of the electrode by the side of the luminescence side of the mounted LED chip and the lead electrode of a package is carried out using a wirebonding device. Next, the resin with which the dispersing agent was mixed is poured in into the crevice of the package of the LED chip circumference.

[0020] After impregnation, a dispersing agent flows and is a wrap about the base of a package. After stiffening the resin of dispersing agent content, impregnation hardening of the resin of a translucency sealing agent is carried out, and the luminescence equipment of this invention is completed. By this, it can consider as the high luminescence equipment of optical extraction effectiveness. Hereafter, the configuration member of this invention is explained in full detail.

[0021] (Light-scattering layer 101) The light-scattering layer 101 of this invention is for taking out outside, without carrying out the guided wave of the light emitted with the lateral vector from the LED chip 103 within the translucency sealing agent 102. Therefore, to be arranged around the LED chip 103 and what is necessary is just dispersion and the thing which can carry out diffuse reflection efficiently about the light from the LED chip 103. Specifically, the inorganic member of light scattering and diffusibility, such as titanium oxide, barium titanate, an aluminum

oxide, oxidization silicon, titanium oxide, a zinc oxide, a piece of a metal, and various fluorescent substances, is mentioned. Furthermore, it can change into an inorganic member and organic resin, such as melamine resin, CTU guanamine resin, and benzoguanamine resin, can also be used.

[0022] It is desirable for translucency to be high to the light from the LED chip 103 as resin which the inorganic member of light scattering and diffusibility contains, and for adhesion with a dispersing agent, the translucency sealing agent 102, and a package 107 and thermal resistance to be high. As such resin, a silicone system, an epoxy system, acrylic resin, etc. are specifically used suitably. The light-scattering layer 101 can be made to form comparatively simply by slushing into the crevice of the package 107 with which the LED chip 103 has been arranged beforehand, and stiffening it. If viscosity of the resin which constitutes the light-scattering layer 101 is made low, it will be easy to spread in the crevice of a package 107. Therefore, it creeps up to the side face which constitutes not only the base of a package 107 but the crevice of a package, or the side face of the LED chip 103.

[0023] Since the LED chip 103 using a nitride semi-conductor has much light emitted from the end face of a luminous layer, using effectively well the light emitted from an end face has big effectiveness especially. If the height from package 107 base to the luminous layer of the LED chip 103 is higher than the thickness of the light-scattering layer 101, the light emitted from an end face will be emitted effectively. Then, by the interface of translucency resin 102 and the exterior, the light which carried out total reflection is a light-scattering layer, and is emitted isotropic.

[0024] Moreover, a light-scattering layer creeps up partially, and since the luminous layer of an LED chip becomes is easy to be emitted it is thin and isotropic [ a wrap case ] from an LED chip end face, light can also be used effectively. Also in this case, the thickness of a light-scattering layer becomes thinner than the height of a luminous layer. this -- creeping up -- it is controllable to some extent by adjusting the viscosity of the resin which constitutes a light-scattering layer. Such a light-scattering layer can obtain uniform luminescence with the comparatively easy configuration of only making a light-scattering layer form on a smooth package.

[0025] (Translucency sealing agent 102) The translucency sealing agent 102 is formed in the crevice of a package 107, and it protects the LED chip 103, a wire 104, etc. from external force, dust, etc. while making the light from the LED chip 103 penetrate outside efficiently. As such a translucency sealing agent 102, an epoxy resin, silicone resin, acrylic resin, etc. are used suitably. In order to give the screen effect etc. to the light from the LED chip 103 into the translucency sealing agent 102, it can add with a coloring color or a color pigment.

[0026] (LED chip 103) the LED chip 103 -- MOCVD -- it can form with law, a liquid phase grown method, etc. by carrying out the laminating of the semi-conductor luminous layers, such as GaP, GaAlAs, GaAlInP, InN, GaN and AlN, InGaP, and InGaAlN, on a substrate. The thing of terrorism structure is mentioned to the gay structure of having MIS junction, PIN junction, pn junction, etc. as structure of an LED chip, hetero structure, and double. Especially through a barrier layer, the light generated in the barrier layer 108 spreads the inside of a barrier layer to double like a waveguide, and the thing of terrorism structure is easy to be emitted to it from the end face of a barrier layer. Therefore, the effectiveness of this invention is large.

[0027] Similarly, a nitride semi-conductor ( $\text{In}_x\text{Ga}_{1-x}\text{Al}_y\text{In}_{1-x-y}\text{N}$ ,  $0 \leq x, 0 \leq y, 0 \leq x+y \leq 1$ ) is formed on insulating silicon on sapphire with difficult crystal growth: in order to supply power to the nitride semi-conductor formed on silicon on sapphire -- a positive electrode and a negative electrode -- the same field side -- not forming -- it does not obtain, but ohmic contact and in order to make a current pour in efficiently, a golden thin film etc. is used as an electrode of translucency. Although such an electrode is used as a thin film, and is giving translucency and it consists of a metal therefore, the light generated by the barrier layer of an LED chip is reflected partially. Therefore, there is much light emitted from an edge and especially the LED chip using a nitride semi-conductor has the large effectiveness of this invention.

[0028] Such an LED chip 103 can use and mount a die bond device on a package 107. Moreover, it can be made to connect with the electrode prepared on the LED chip electrically using wire

104 grade.

[0029] (Package 107) The lead electrode 105 which a package 107 makes arrange the LED chip 103, and supplies the current from the outside to the LED chip 103 is formed. As a concrete ingredient of such a package 107, insulating supporter material, such as ceramics, and a liquid crystal polymer, PBT resin, is mentioned suitably. In order to take out the light from the LED chip 103 efficiently, a thing with a side attachment wall is suitably mentioned to a package 107.

[0030] When carrying out mold shaping of the package 107 with resin, the lead electrode 105 which supplies power to the LED chip 103 arranged inside can be formed comparatively easily by insert molding etc. The lead electrode 105 can be formed with electric good conductors; such as metallizing, such as nickel, or phosphor bronze. In order to raise the reflexivity of the light from the LED chip 103, smooth metal plating, such as silver, aluminum, and copper metallurgy, can also be performed to the front face of the lead electrode 105. In order to reflect the light from the LED chip 103 efficiently, the resin which constitutes a package 107 can be made to mix white pigments, such as barium titanate, etc.

[0031] When making a ceramic constitute a package 107, the conductive paste which contained the refractory metal by the desired pattern on the green sheet used as the raw material before ceramic baking is printed. It calcinates, after setting a green sheet in two or more [-fold] and making it a package configuration, and a ceramic package is formed. A conductive paste remains as an electrode layer in which electrical installation with the jump exterior has a possible resinous principle at the time of baking.

[0032] In addition, a smooth package base means the flat surface which can be reflected in the specific direction like a mirror plane for the great portion of light from the LED chip 103 which carried out incidence from fixed. The light of the lengthwise direction emitted from the LED chip 103 arranged on such a flat surface can be efficiently emitted to a front face. It cannot be overemphasized that it is not what is limited only to this hereafter although the concrete example of this invention is explained in full detail.

[0033]

[Example] The LED chip which had the nitride semi-conductor with which blue (470nm) can emit light in the luminous layer as a chip type LED was arranged in the resin package. The laminating of the buffer layer to which an LED chip consists of gallium nitride on silicon on sapphire, n mold contact-cum-the cladding layer which consists of GaN, p mold cladding layer which consists of GaAlN, and the p mold contact layer which consists of GaN is carried out. Between n mold contact layer and p mold cladding layer, the InGaN layer used as single quantum well structure is formed. In order to make the electrode of a positive electrode and a negative electrode form from the semi-conductor layer side formed on silicon on sapphire, some nitride semi-conductors are made to etch and n mold contact layer is exposed. The golden thin film is made to have formed as an ohmic electrode on p mold contact layer.

[0034] Molding of the package was carried out by arranging the lead electrode made to form beforehand in metal mold, and carrying out impregnation hardening of the liquid crystal polymer. Some lead electrodes have exposed the formed package to the base of opening, and the front face of a lead electrode, the base of a package, and the side face have made light from an LED chip the efficient smooth side which can be reflected.

[0035] The translucency epoxy resin was used into opening of a package, and the above-mentioned LED chip was made to mount by the die bonding device. Wirebonding of each electrode of an LED chip and the lead electrode in package opening is carried out using a gold streak, and the flow is taken electrically.

[0036] It was made to pour into package opening circles, carrying out mixed stirring of the thing which made 5g of barium titanate, and a blue color contain in 100g of silicone resin as a light-scattering layer. It was made to harden in 150-degree-C 30 minutes, and the light-scattering layer was made to form after impregnation. Although the height of the formed light-scattering layer was lower than the luminous layer of an LED chip, the light-scattering layer was creeping up thinly at the edge. Into the crevice of a package, impregnation hardening has been carried out by using an epoxy resin as a translucency sealing agent in 120-degree-C 2 hours. In this way, 500 chip types LED were formed and the luminescence property was investigated.

[0037] 500 chip types LED as well as the chip type LED of this invention were made to form except not forming a light-scattering layer for a comparison.

[0038] Although all emitted light when the current was supplied to the formed chip type LED, as for the chip type LED in which the whole opening made the chip type LED of this invention form to emitting light blue for this invention and a comparison, light is notably emitted near the LED chip blue. Moreover, the average luminescence brightness of the chip type LED which did not prepare a light-scattering layer was set to 100, and the chip type LED which prepared the light-scattering layer was increased about twenty percent, and was detected brightly. Thereby, it turned out with the configuration with the very easy luminescence equipment of this invention that a radiant power output may be improved sharply.

[0039]

[Effect of the Invention] The light-scattering layer which is made to scatter about for it and diffuse the reflecting surface reflected in the front face of direct from an LED chip and the light by which total reflection was carried out with the translucency sealing agent, and is efficiently taken out outside by the configuration of this invention is made to carry out functional separation. This raises the optical extraction effectiveness from luminescence equipment. Moreover, when arranging in a package the LED chip which emits light in the luminescence wavelength from which plurality differs, since light spreads in homogeneity by the light-scattering layer, light can be emitted with sufficient color mixture nature.

[0040] With the luminescence equipment of this invention according to claim 2, it takes out without affecting luminescence [ chip / LED ], and only effectiveness may be improved. That is, the luminescence brightness emitted from the edge of a luminous layer is not reduced. Moreover, the light by which critical reflection is carried out can be chosen and external extraction effectiveness can be raised.

[0041] With the luminescence equipment of this invention according to claim 3, an LED chip does not emit light in a package at punctiform. That is, a light-emitting part can be more greatly observed as the LED chip is arranged like the time of an astigmatism LGT at the whole opening at the time of lighting. For example, if the luminescence wavelength of a light emitting device is a blue field, it can also make to consider as \*\*\*\*\* etc. into a color with a high reflection factor only to the luminescent color by adding the blue system pigment of light scattering and diffusibility to a light-scattering layer. In this case, if the luminescent color of a light emitting device and the color of a light-scattering layer are doubled, it will also become possible not to make the luminescent color of luminescence equipment actually emit light, but to distinguish it easily visually.

[0042] With the luminescence equipment of this invention according to claim 4, when it is a light emitting device with much lateral light emission, optical extraction effectiveness can be raised by leaps and bounds. With the luminescence equipment of this invention according to claim 5, light from an LED chip can be made efficient dispersion and diffuse reflection.

[Brief Description of the Drawings]

[Drawing 1] The chip type LED typical sectional view by one example of this invention is shown.

[Drawing 2] In the chip type LED shown for this invention and a comparison, the course of the light by which outgoing radiation was carried out the include angle [ chip / LED ] beyond a critical angle is shown typically.

[Drawing 3] In the chip type LED of this invention, the path of the light by which outgoing radiation was carried out the include angle [ chip / LED ] beyond a critical angle is shown typically.

[Drawing 4] It is the typical sectional view of the chip type LED shown for this invention and a comparison.

[Description of Notations]

100 ... Luminescence equipment

101 ... Light-scattering layer

102 ... Translucency sealing agent

103 ... LED chip

104 ... Wire

105 ... Lead electrode  
106 ... Mounting resin  
107 ... Package  
108 ... Barrier layer  
200 ... Luminescence equipment  
202 ... Translucency resin  
203 ... Point of the LED chip seen typically emitting light  
208 ... Light by which outgoing radiation was carried out from the LED chip above the critical angle  
209 ... Light by which critical angle reflection was carried out  
210 ... Light repeatedly reflected with a translucency sealing agent  
301 ... Light-scattering layer  
302 ... Translucency resin  
303 ... Point of the LED chip seen typically emitting light  
308 ... Light by which outgoing radiation was carried out from the LED chip above the critical angle  
309 ... Light by which critical angle reflection was carried out  
310 ... Light which diffuses and reflects and is emitted in the shape of a semi-sphere  
311 ... Light which goes to true down one from an LED chip  
400 ... Luminescence equipment  
402 ... Translucency sealing agent  
403 ... LED chip  
404 ... Gold streak  
405 ... Lead electrode  
406 ... Die bond resin  
407 ... Package

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[Translation done.]